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Lamarre et al.

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(54) **COMPOUND ENGINE ASSEMBLY WITH OFFSET TURBINE SHAFT, ENGINE SHAFT AND INLET DUCT**

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F01C 11/00 (2006.01)

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(Continued)

(58) **Field of Classification Search**

CPC F01C 11/008; F01C 1/22; F01C 21/18; F02B 41/00; F02C 6/12; F02C 6/206;

(Continued)

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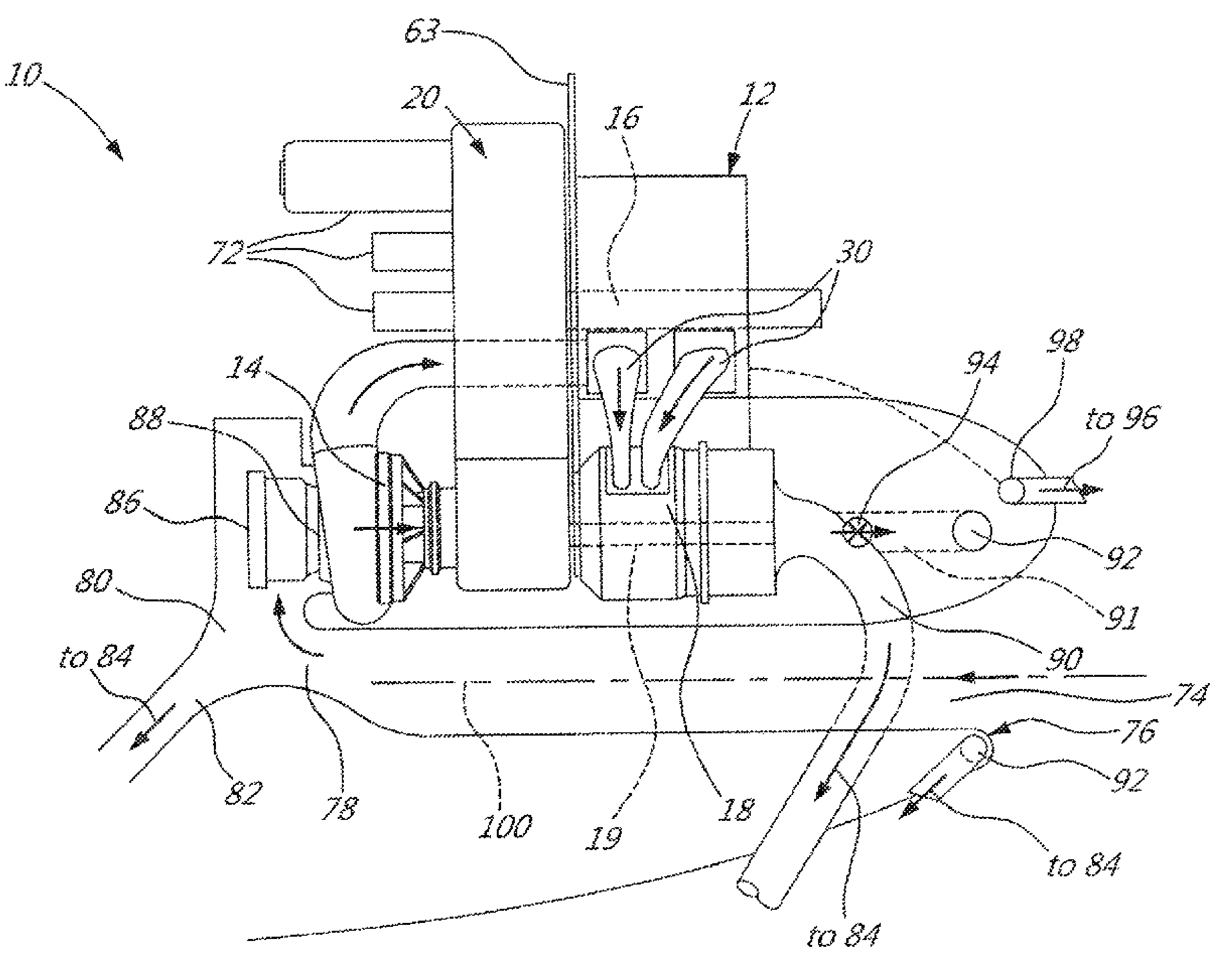
(57) **ABSTRACT**

A compound engine assembly with an inlet duct, a compressor, an engine core including at least one internal combustion engine, and a turbine section including a turbine shaft configured to compound power with the engine shaft. The turbine section may include a first stage turbine and a second stage turbine. The turbine shaft and the engine shaft are parallel to each other. The turbine shaft, the engine shaft and at least part of the inlet duct are all radially offset from one another. A method of driving a rotatable load of an aircraft is also discussed.

17 Claims, 11 Drawing Sheets



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(51) **Int. Cl.**

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F02C 6/20	(2006.01)
F02C 7/052	(2006.01)
F02C 7/36	(2006.01)
F01C 21/18	(2006.01)
F01C 1/22	(2006.01)

(52) **U.S. Cl.**

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CPC F02C 7/052; F02C 7/36; F05B 2220/40; F05D 2220/323

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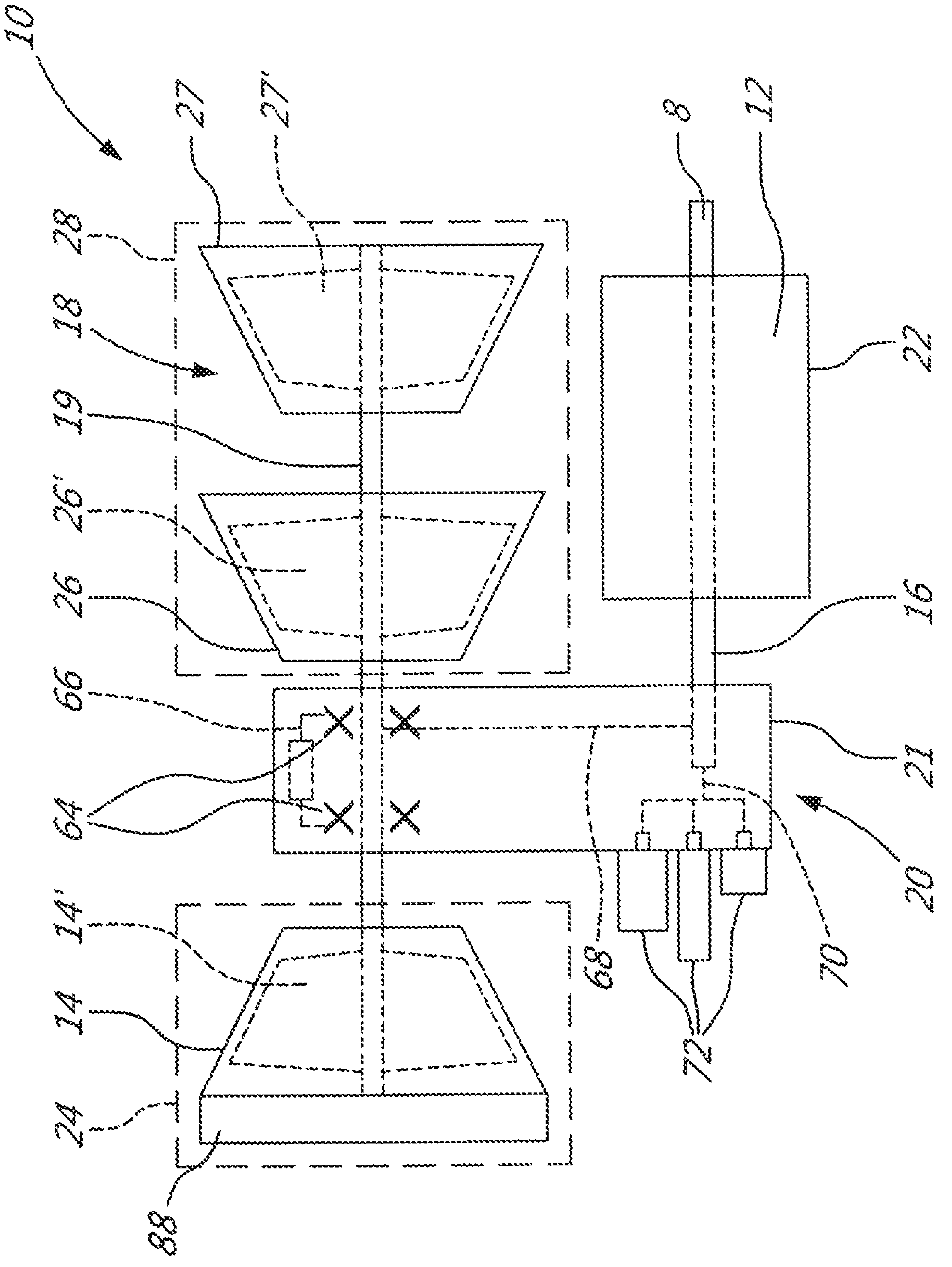


FIG. 1

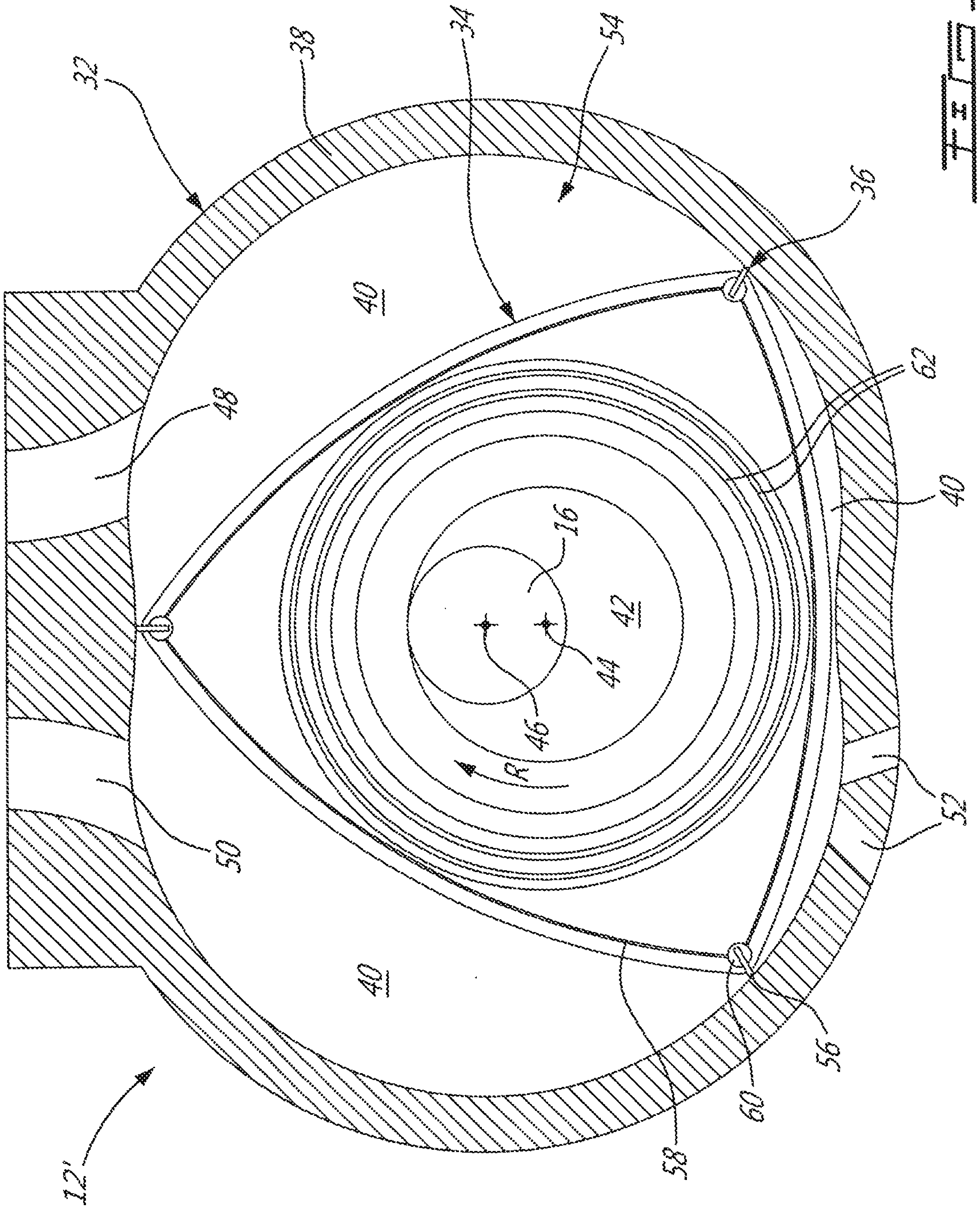


FIG. 2

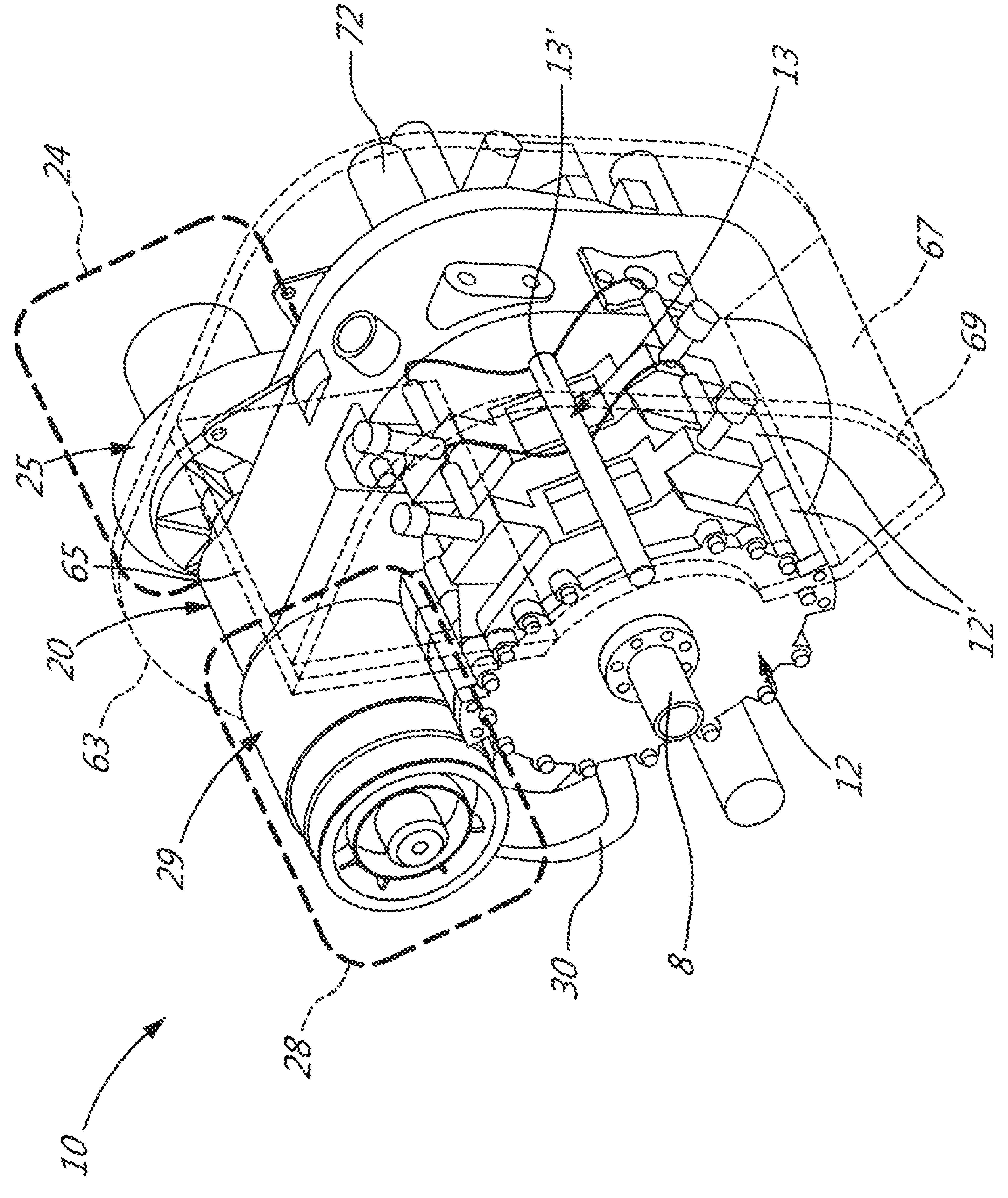
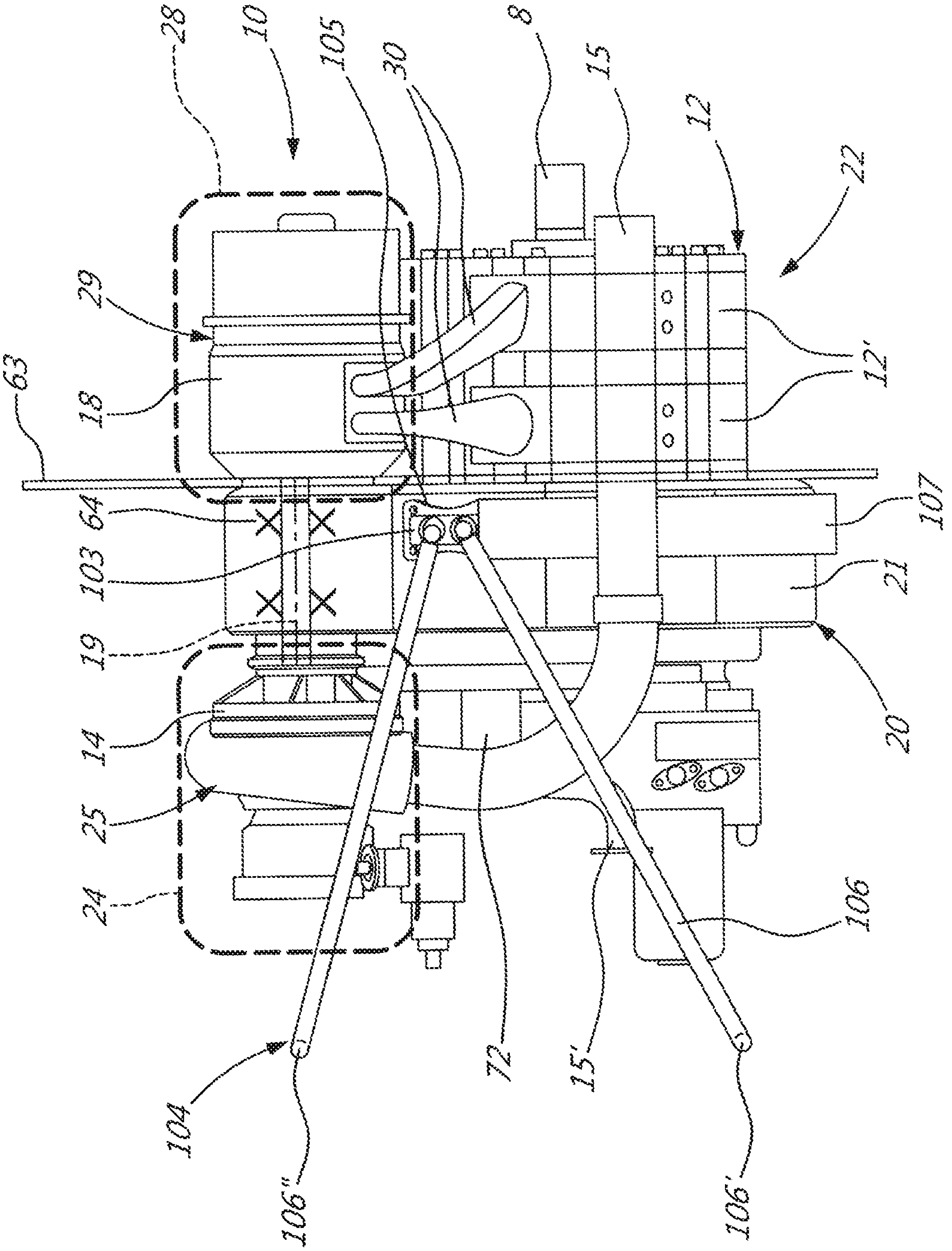


FIG. 3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8
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22
29
18
63
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12'
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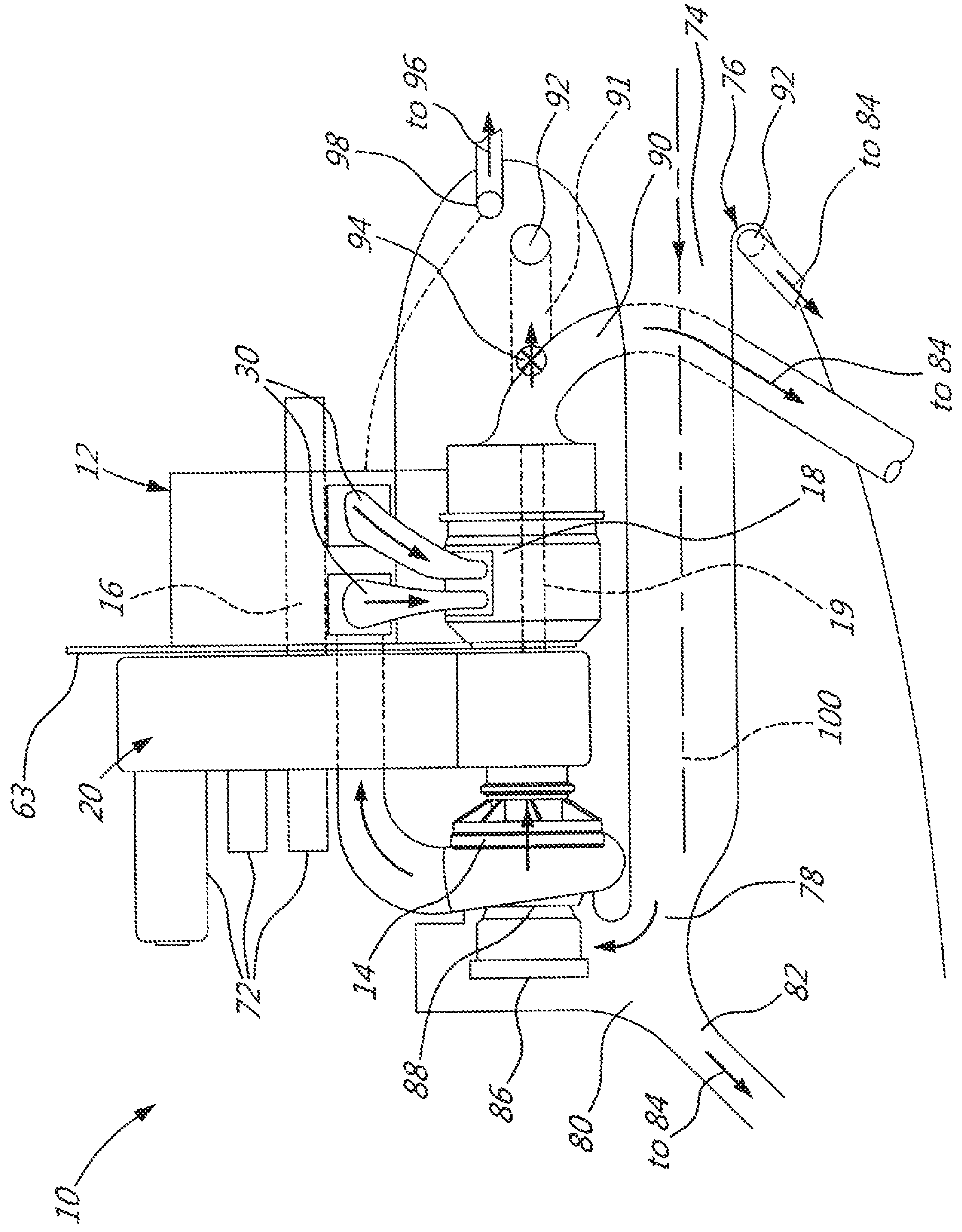
19
14
25
24
107
21
20
106
72
15'
104
106"
106'

FIG. 4



to 96
98
92
91
94
90
74
76
92
to 84
30
to 84
12
18
16
19
63
20
100
72
14
78
88
86
80
82
to 84
10

FIG. 5

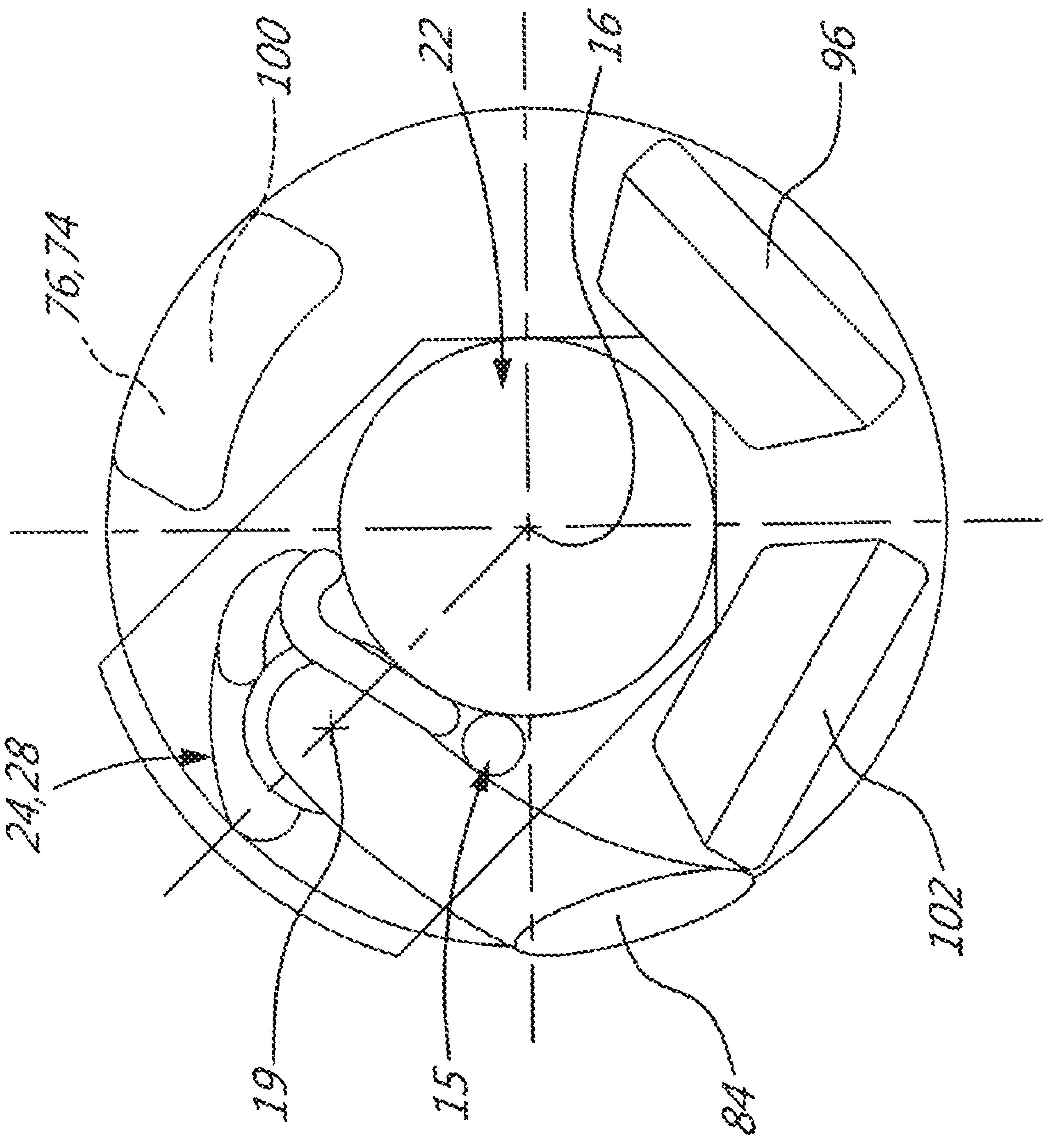


FIG. 6

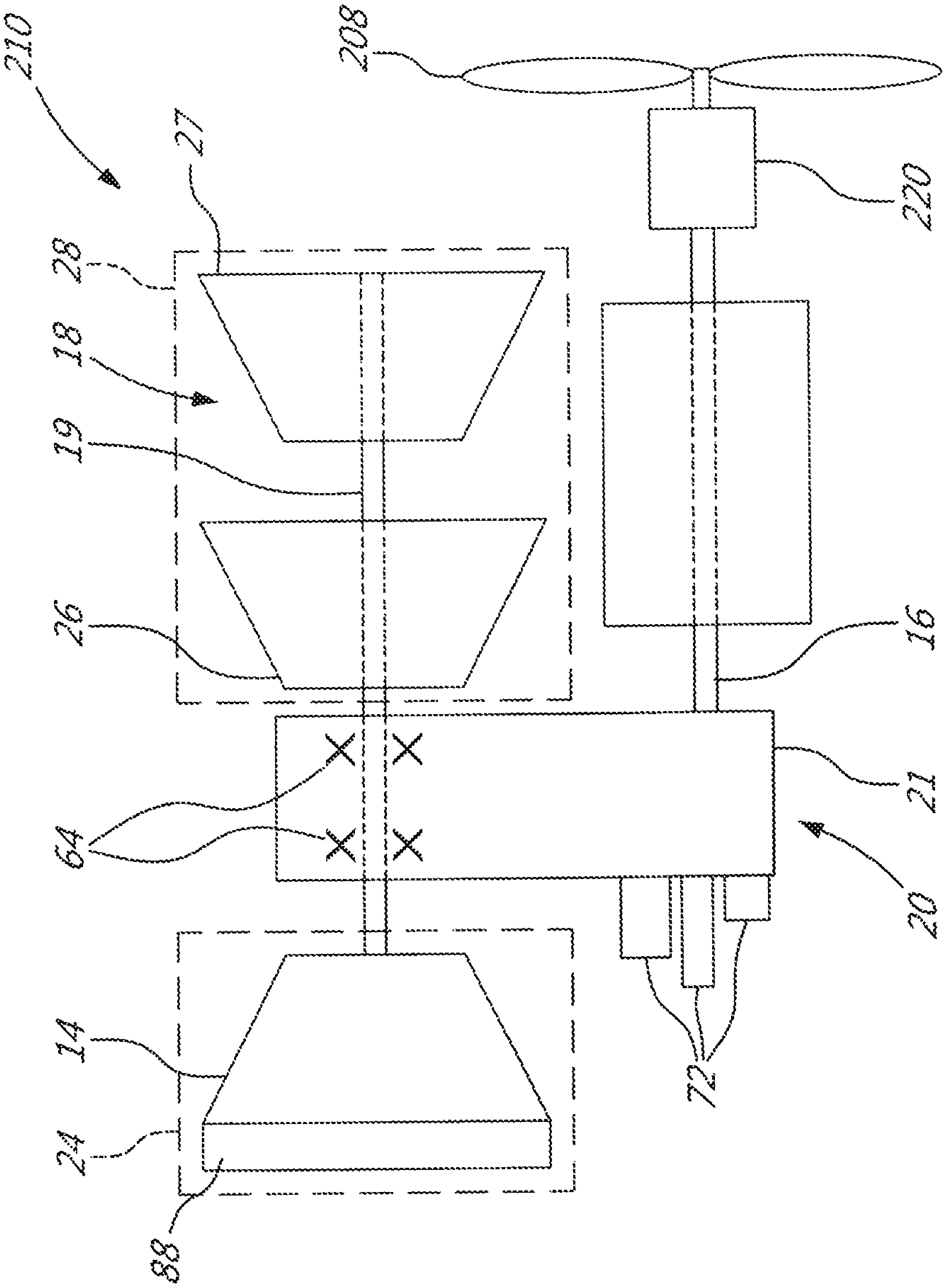


FIG. 7

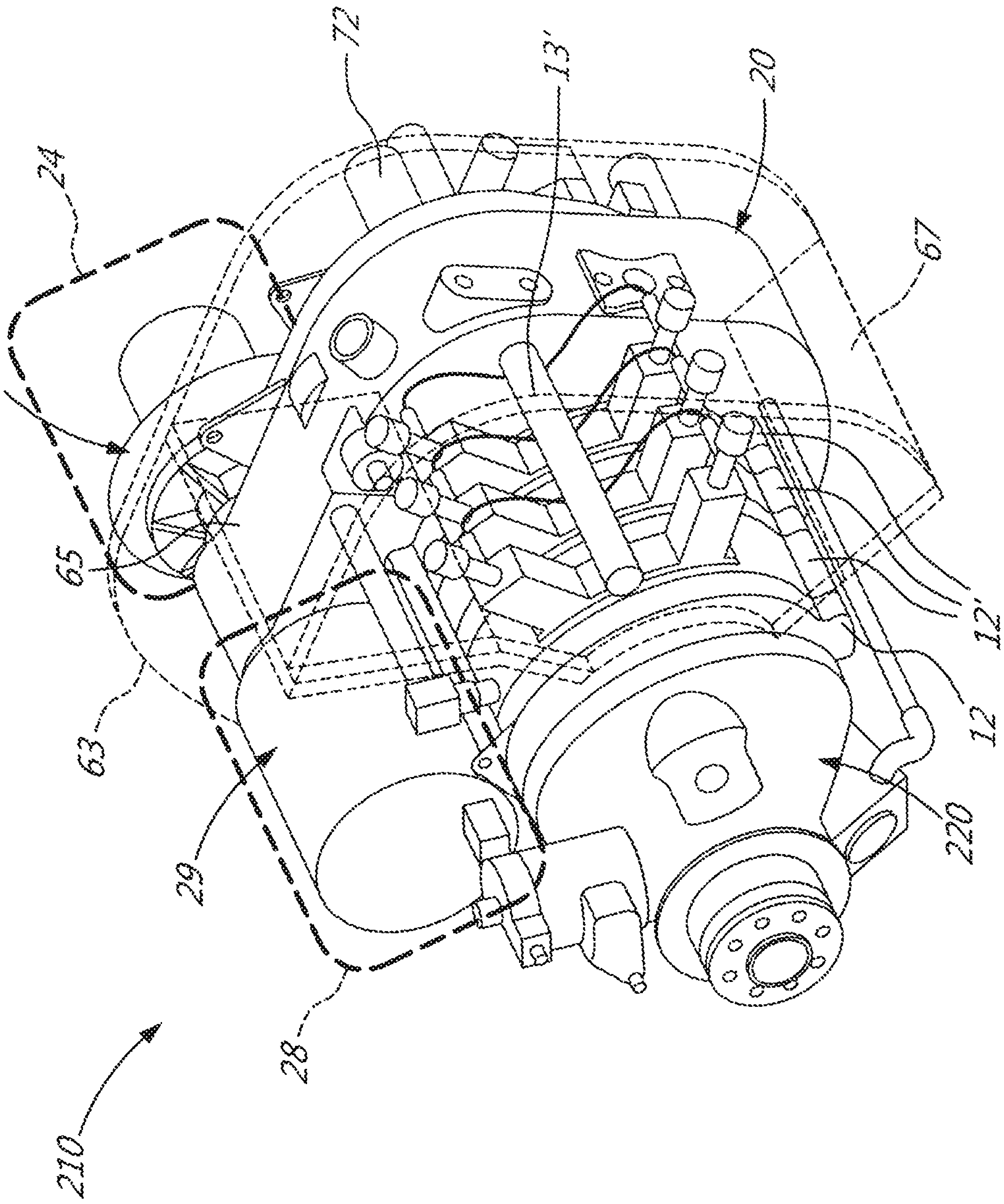
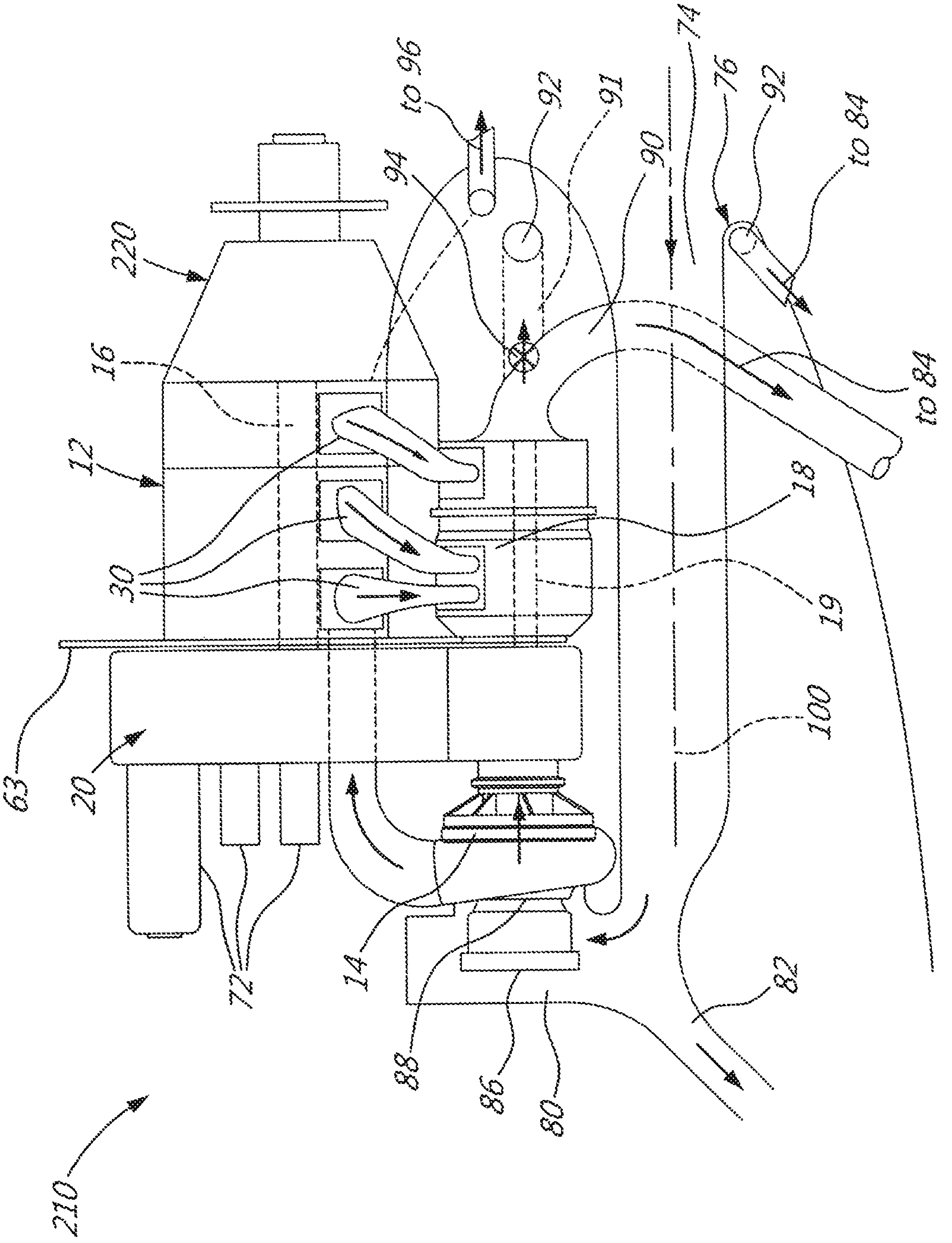


FIG. 8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20
72
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91
92
94
to 96

FIG. 9

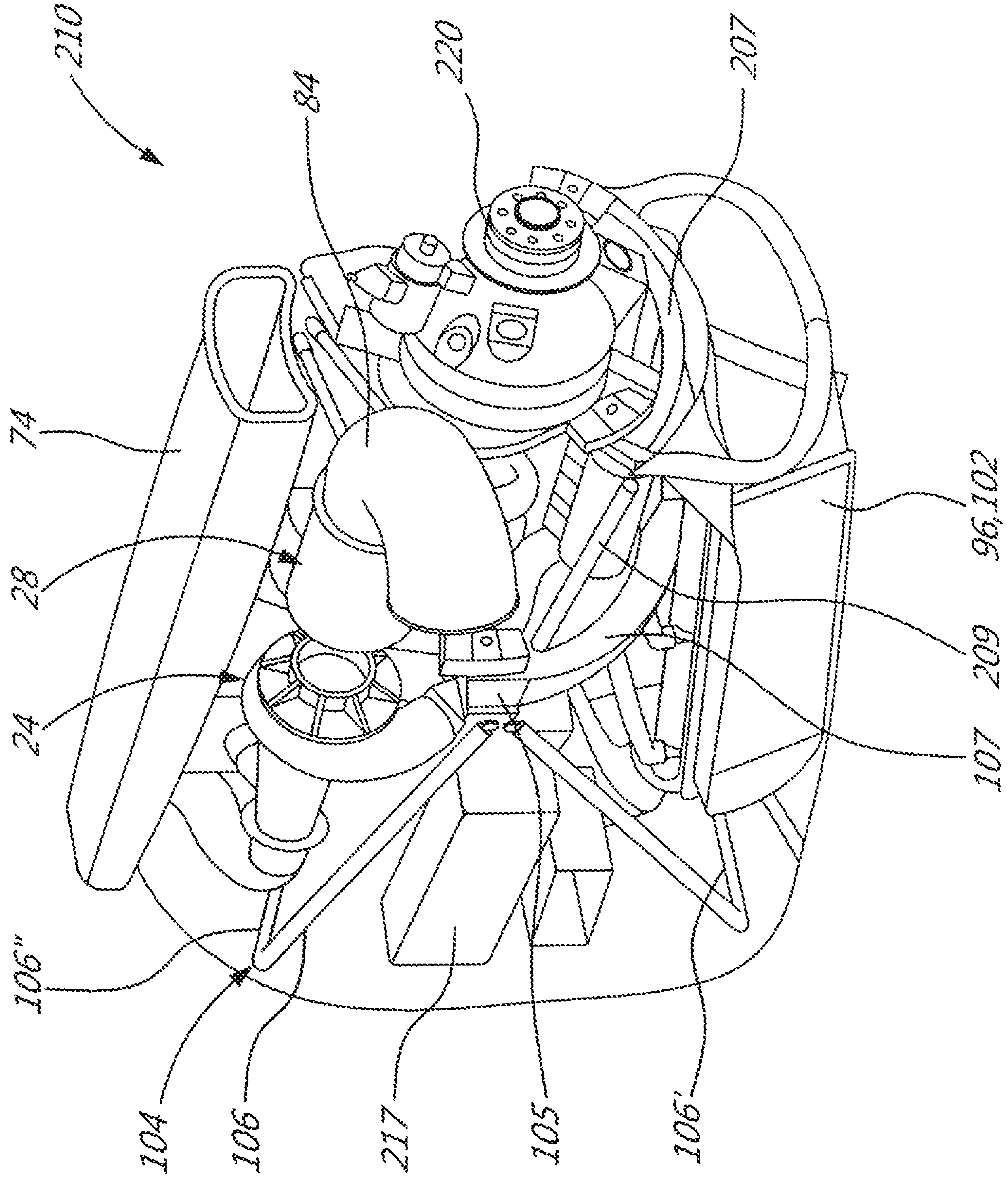
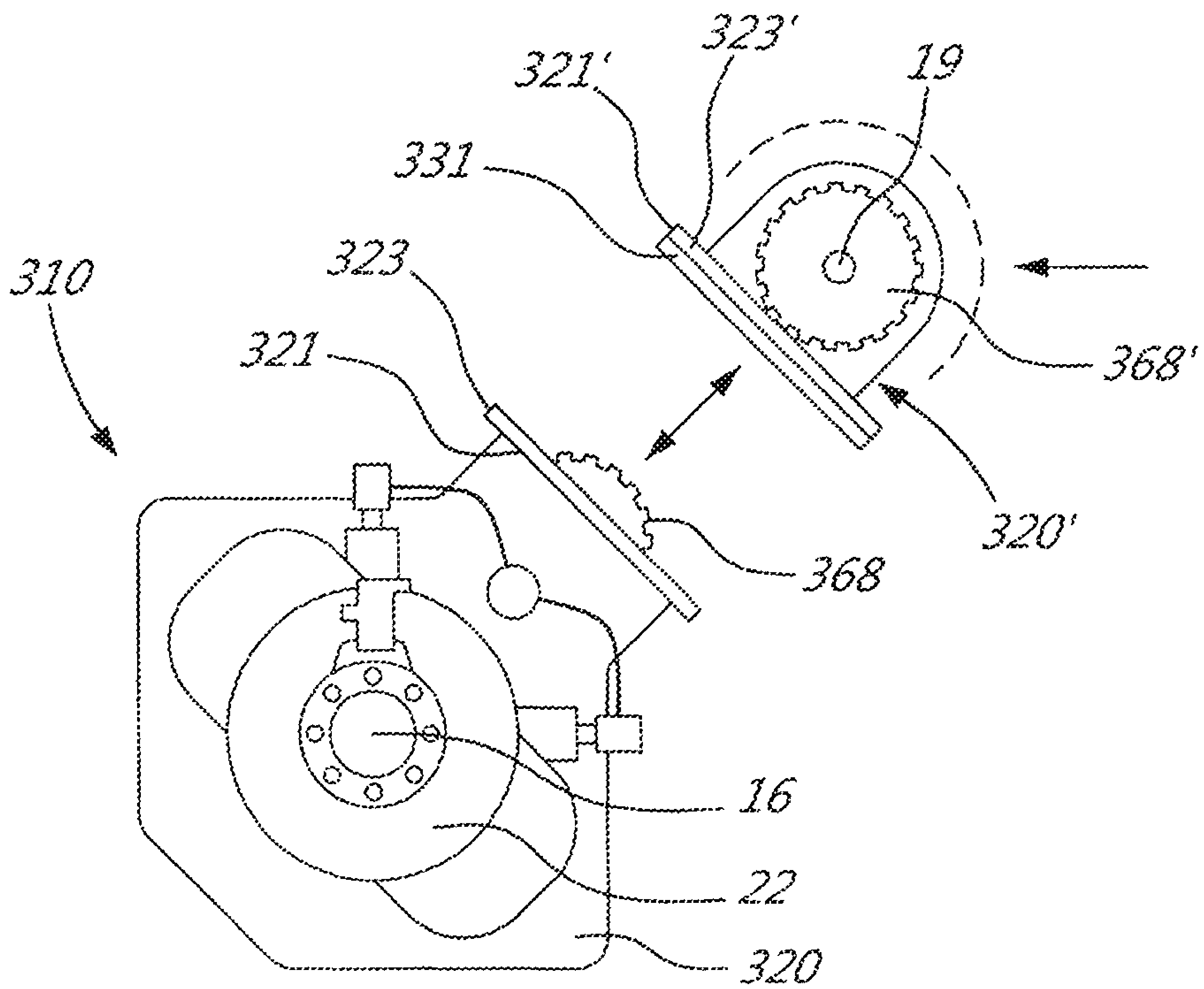


FIG. 10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368
16
22
320

FIG. 11

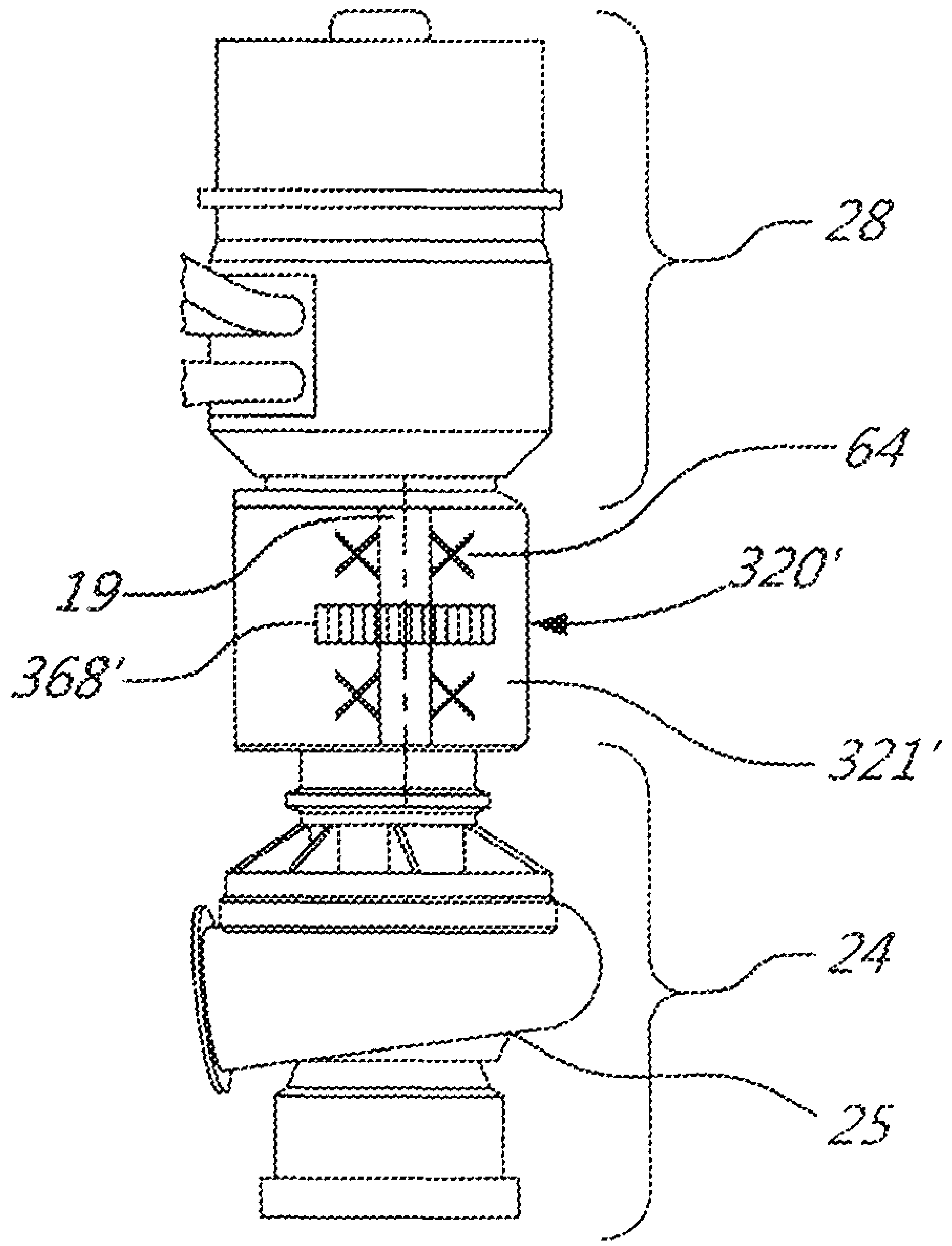
28
64
320'
19
368'
321'
24
25

FIG. 12

COMPOUND ENGINE ASSEMBLY WITH OFFSET TURBINE SHAFT, ENGINE SHAFT AND INLET DUCT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 14/864,096, filed Sep. 24, 2015, which claims priority from U.S. provisional application No. 62/118,914 filed Feb. 20, 2015, the entire contents of which are incorporated by reference herein.

TECHNICAL FIELD

The application relates generally to compound engine assemblies and, more particularly, to supercharged or turbocharged compound engine assemblies used in aircraft.

BACKGROUND OF THE ART

Compound engine assemblies including a compressor used as a supercharger or turbocharger may define a relatively bulky assembly which may be difficult to fit into existing aircraft nacelles, thus creating some difficulty in adapting them for aircraft applications.

SUMMARY

In one aspect, there is provided a compound engine assembly comprising: an inlet duct having an inlet in fluid communication with ambient air around the compound engine assembly; a compressor having an inlet in fluid communication with the inlet duct, the compressor including at least one compressor rotor connected to a turbine shaft; an engine core including at least one internal combustion engine in driving engagement with an engine shaft, the engine core having an inlet in fluid communication with an outlet of the compressor; a turbine section having an inlet in fluid communication with an outlet of the engine core, the turbine section including at least one turbine rotor connected to the turbine shaft, the turbine shaft configured to compound power with the engine shaft; wherein the turbine shaft and the engine shaft are parallel to each other; and wherein the turbine shaft, the engine shaft and a longitudinal central axis of at least part of the inlet duct are all radially offset from one another.

In another aspect, there is provided a compound engine assembly comprising: an inlet duct having an inlet in fluid communication with ambient air around the compound engine assembly; a compressor having an inlet in fluid communication with the inlet duct; an engine core including at least one internal combustion engine in driving engagement with an engine shaft, the engine core having an inlet in fluid communication with an outlet of the compressor; a turbine section including a first stage turbine having an inlet in fluid communication with the outlet of the engine core and a second stage turbine having an inlet in fluid communication with an outlet of the first stage turbine, each of the first stage turbine and the second stage turbine including at least one rotor connected to a turbine shaft, the turbine shaft and the engine shaft being in driving engagement with one another; wherein the turbine shaft and the engine shaft are parallel to each other; and wherein the turbine shaft, the engine shaft at least part of the inlet duct are all radially offset from one another.

In a further aspect, there is provided a method of driving a rotatable load of an aircraft, the method comprising: directing ambient air from outside of the compound engine assembly into the compound engine assembly through an inlet duct; directing the air from the inlet duct to an inlet of a compressor; directing compressed air from an outlet of a compressor to an inlet of at least one internal combustion engine of a compound engine assembly; driving rotation of an engine shaft with the at least one combustion engine; driving rotation of a turbine shaft of a turbine section of the compound engine assembly by circulating an exhaust of the at least one internal combustion engine to an inlet of the turbine section; and compounding power from the turbine shaft with that of the engine shaft to drive the rotatable load; wherein the turbine shaft and the engine shaft are parallel to each other and radially offset with respect to each other; and wherein the air is circulated through the inlet duct along a path radially offset from the turbine shaft and from the engine shaft.

DESCRIPTION OF THE DRAWINGS

Reference is now made to the accompanying figures in which:

FIG. **1** is a schematic view of a compound engine assembly in accordance with a particular embodiment;

FIG. **2** is a cross-sectional view of a Wankel engine which can be used in a compound engine assembly such as shown in FIG. **1**, in accordance with a particular embodiment;

FIG. **3** is a schematic tridimensional view of the compound engine assembly of FIG. **1** in accordance with a particular embodiment;

FIG. **4** is a schematic side view of the compound engine assembly of FIG. **3**, with an engine mount in accordance with a particular embodiment;

FIG. **5** is a schematic cross-sectional side view of the compound engine assembly of FIG. **3**, with an inlet duct and firewall according to a particular embodiment;

FIG. **6** is a schematic front view of the compound engine assembly of FIG. **3**, according to a particular embodiment;

FIG. **7** is a schematic view of a compound engine assembly in accordance with another particular embodiment;

FIG. **8** is a schematic tridimensional view of the compound engine assembly of FIG. **7** in accordance with a particular embodiment;

FIG. **9** is a schematic cross-sectional side view of the compound engine assembly of FIG. **8**, with an inlet duct and firewall according to a particular embodiment;

FIG. **10** is a schematic tridimensional view of the compound engine assembly of FIG. **8**, with an engine mount in accordance with a particular embodiment;

FIG. **11** is a schematic, exploded end view of a compound engine assembly in accordance with another particular embodiment; and

FIG. **12** is a schematic side view of part of the compound engine assembly of FIG. **11**.

DETAILED DESCRIPTION

Referring to FIG. **1**, a compound engine assembly **10** is generally shown, including a liquid cooled heavy fueled multi-rotor rotary engine core **12**. The engine core **12** has an engine shaft **16** driven by the engine core **12** and driving a rotatable load, which is shown here as a drive shaft **8**. The drive shaft **8** may be an integral part of the engine shaft **16**, be directly connected thereto, or be connected thereto through a gearbox (not shown). It is understood that the compound engine assembly **10** may alternately be configured to drive any other appropriate type of load, including, but not limited to, one or more generator(s), propeller(s), accessory(ies), rotor mast(s), compressor(s), or any other appropriate type of load or combination thereof.

The compound engine assembly **10** is configured as a single shaft engine. The term “single shaft” is intended herein to describe a compound engine where all the rotating components (compressor rotor(s), turbine rotor(s), engine shaft, accessories) are mechanically linked together, either directly or through one more gearbox(es). Accordingly, a “single shaft” engine may include two or more mechanically linked shafts. The term “single shaft” is intended to be in contrast to an engine having two or more spools which are free to rotate with respect to one another such as to include one or more free turbine(s).

The compound engine assembly **10** includes a compressor **14** feeding compressed air to the inlet of the engine core **12** (corresponding to or communicating with the inlet port of each engine of the engine core **12**). The engine core **12** receives the pressurized air from the compressor **14** and burns fuel at high pressure to provide energy. Mechanical power produced by the engine core **12** drives the engine shaft **16**. Each engine of the engine core **12** provides an exhaust flow in the form of exhaust pulses of high pressure hot gas exiting at high peak velocity. The outlet of the engine core **12** (corresponding to or communicating with the exhaust port of each engine of the engine core **12**) is in fluid communication with an inlet of a turbine section **18**, and accordingly the exhaust flow from the engine core **12** is supplied to the turbine section **18**. The turbine section **18** drives the compressor **14** and compounds power with the engine shaft **16**.

In a particular embodiment, the compound engine assembly includes four (4) major modules: a core module **22** including the engine core **12**, a gearbox module **20**, a cold section or compressor module **24** including the compressor **14** and a hot section or turbine module **28** including the turbine section **18**. In a particular embodiment, the turbine module **28** and compressor module **24** are removable by typical maintenance personnel, in the field, with the compound engine assembly **10** remaining attached to the aircraft, for ease of maintenance, repair and/or replacement. In a particular embodiment, each of the turbine module **28**, compressor module **24** and core module **22** can be detached and removed from the compound engine assembly **10** in an individual and separate manner, i.e. without the need to detach/remove any of the other modules; in a particular embodiment, the components of each module are thus contained in and/or mounted to a casing which defines an enclosure independently of that of the other modules. In a particular embodiment, the modularity of the compound engine assembly **10** may allow reducing or minimizing the number of parts in the compound engine assembly **10** and/or may enable each module to run at speeds corresponding to optimum performance conditions.

Referring to FIG. **3**, the core module **22** includes the engine core **12** and a fuel distribution system **13**. In the embodiment show, the engine core **12** includes a plurality of rotary engines **12'** drivingly engaged to the shaft **16**, and the fuel distribution system **13** includes a common rail **13'** feeding a pilot and a main injector for each rotary engine. Although the engine core **12** is depicted as including two rotary engines **12'**, it is understood that in another embodiment, the engine core **12** may include more than two rotary engines **12'** (e.g. 3 or 4 rotary engines), or a single rotary engine **12'**. Each rotary engine **12'** has a rotor sealingly engaged in a respective housing, with each rotary engine **12'** having a near constant volume combustion phase for high cycle efficiency. In the embodiment shown, each rotary engine **12'** is a Wankel engine.

Referring to FIG. **2**, an exemplary embodiment of a Wankel engine which may be used as rotary engine **12'** in the engine core **12** is shown. Each Wankel engine **12'** comprises a housing **32** defining an internal cavity with a profile defining two lobes, which is preferably an epitrochoid. A rotor **34** is received within the internal cavity. The rotor defines three circumferentially-spaced apex portions **36**, and a generally triangular profile with outwardly arched sides. The apex portions **36** are in sealing engagement with the inner surface of a peripheral wall **38** of the housing **32** to form three working chambers **40** between the rotor **34** and the housing **32**.

The rotor **34** is engaged to an eccentric portion **42** of the shaft **16** to perform orbital revolutions within the internal cavity. The shaft **16** performs three rotations for each orbital revolution of the rotor **34**. The geometrical axis **44** of the rotor **34** is offset from and parallel to the axis **46** of the housing **32**. During each orbital revolution, each chamber **40** varies in volume and moves around the internal cavity to undergo the four phases of intake, compression, expansion and exhaust.

An intake port **48** is provided through the peripheral wall **38** for successively admitting compressed air into each working chamber **40**. An exhaust port **50** is also provided through the peripheral wall **38** for successively discharging the exhaust gases from each working chamber **40**. Passages **52** for a glow plug, spark plug or other ignition element, as well the fuel injectors are also provided through the peripheral wall **38**. Alternately, the intake port **48**, the exhaust port **50** and/or the passages **52** may be provided through an end or side wall **54** of the housing; and/or, the ignition element and a pilot fuel injector may communicate with a pilot subchamber (not shown) defined in the housing **32** and communicating with the internal cavity for providing a pilot injection. The pilot subchamber may be for example defined in an insert (not shown) received in the peripheral wall **38**.

In the embodiment of FIG. **3**, the fuel injectors are common rail fuel injectors, and communicate with a source of Heavy fuel (e.g. diesel, kerosene (jet fuel), equivalent biofuel), and deliver the heavy fuel into the engine(s) such that the combustion chamber is stratified with a rich fuel-air mixture near the ignition source and a leaner mixture elsewhere.

Referring back to FIG. **2**, for efficient operation the working chambers **40** are sealed, for example by spring-loaded apex seals **56** extending from the rotor **34** to engage the peripheral wall **38**, and spring-loaded face or gas seals **58** and end or corner seals **60** extending from the rotor **34** to engage the end walls **54**. The rotor **34** also includes at least one spring-loaded oil seal ring **62** biased against the end wall **54** around the bearing for the rotor **34** on the shaft eccentric portion **42**.

Each Wankel engine provides an exhaust flow in the form of a relatively long exhaust pulse; for example, in a particular embodiment, each Wankel engine has one explosion per 360° of rotation of the shaft, with the exhaust port remaining open for about 270° of that rotation, thus providing for a pulse duty cycle of about 75%. By contrast, a piston of a reciprocating 4-stroke piston engine typically has one explosion per 720° of rotation of the shaft with the exhaust port remaining open for about 180° of that rotation, thus providing a pulse duty cycle of 25%.

In a particular embodiment which may be particularly but not exclusively suitable for low altitude, each Wankel engine has a volumetric expansion ratio of from 5 to 9, and operates following the Miller cycle, with a volumetric compression ratio lower than the volumetric expansion ratio, for example by having the intake port located closer to the top dead center (TDC) than an engine where the volumetric compression and expansion ratios are equal or similar. Alternately, each Wankel engine may operate with similar or equal volumetric compression and expansion ratios.

It is understood that other configurations are possible for the engine core **12**. The configuration of the engine(s) **12'** of the engine core **12**, e.g. placement of ports, number and placement of seals, number of fuel injectors, etc., may vary from that of the embodiment shown. In addition, it is understood that each engine **12'** of the engine core **12** may be any other type of internal combustion engine including, but not limited to, any other type of rotary engine, and any other type of non-rotary internal combustion engine such as a reciprocating engine.

Referring back to FIG. **1**, in a particular embodiment the compressor **14** is a centrifugal compressor with a single impeller **14'**. Other configurations are alternately possible. The compressor **14** may be single-stage device or a multiple-stage device and may include one or more rotors having a circumferential array of radial, axial or mixed flow blades.

Referring to FIG. **3**, the gearbox module **20** includes a casing **21** containing (e.g. enclosing) at least one gear train, and the compressor module **24** includes a casing **25** located outside of the gearbox module casing **21**. The compressor module casing **25** contains (e.g. encloses) the compressor rotor(s) **14'** (e.g. impeller), diffuser, shroud, inlet scroll, and variable inlet guide vanes **88** (see FIG. **1**) through which the air circulates before reaching the compressor rotor(s). The compressor module casing **25** may include a plurality of casing pieces cooperating to define an enclosure containing the compressor **14**, and/or may be defined in whole or in part by outer walls of the compressor **14**. Referring to FIGS. **3-4**, the compressor module casing **25** is mounted on a face of the gearbox module casing **21**. In a particular embodiment, the compressor module casing **25** and the gearbox module casing **21** are detachably interconnected, for example by having abutting flanges of the casings **25**, **21** interconnected by bolts and/or clamps or through the use of any other appropriate type of fasteners, including, but not limited to, such engagement members or fasteners defining a type of connection known as "quick access disconnect". Other configurations are also possible.

Referring to FIG. **4**, in a particular embodiment the communication between the outlet of the compressor **14** and the inlet of the engine core **12** is performed through an intake manifold **15**. In a particular embodiment, the compressor rotor(s) are sized to supply engine mass flow and cabin air bleed. The intake manifold **15**, which may be provided separately from the compressor module **24**, includes a branch-off port **15'** for pressurized cabin bleed air.

The turbine module **28** includes a turbine module casing **29** containing (e.g. enclosing) the turbine section **18**, including at least one rotor connected to a turbine shaft **19**, with respective turbine vane(s), housing(s), containment feature(s) and tie-bolt(s). The turbine module casing **29** is spaced from the compressor module casing **25** and also located outside of the gearbox module casing **21**. The turbine module casing **29** may include a plurality of casing pieces cooperating to define an enclosure containing the turbine section **18** and/or may be defined in whole or in part by outer walls of the turbine section **18**. The turbine module casing **29** is mounted on the face of the gearbox module casing **21** opposite that receiving the compressor module casing **25**; in a particular embodiment, the turbine module casing **29** is mounted on the forward face of the gearbox module casing **21**. In a particular embodiment, the turbine module casing **29** and the gearbox module casing **21** are detachably interconnected, for example by having abutting flanges of the casings **29**, **21** interconnected by bolts and/or clamps or through the use of any other appropriate type of fasteners, including, but not limited to, such engagement members or fasteners defining a type of connection known as "quick access disconnect". Other configurations are also possible.

A plurality of exhaust pipes **30** provide the fluid communication between the outlet of the engine core **12** (exhaust port of each engine **12'**) and the inlet of the turbine section **18**. The core module **22** is mounted on the same face of the gearbox module casing **21** as the turbine module **28**; in a particular embodiment, close-coupling of the turbine module **28** to the core module **22** helps increase (and preferably maximize) exhaust gas energy recovery by keeping the exhaust pipes **30** between the engine core **12** and the turbine section **18** as short as possible and controlling the flow area throughout. The exhaust pipes **30** become very hot during use, and accordingly appropriate materials selection and cooling is implemented to ensure their durability.

As can be seen in FIG. **1**, the turbine section **18** may include one or more turbine stages contained in the turbine module casing. In a particular embodiment, the turbine section **18** includes a first stage turbine **26** receiving the exhaust from the engine core **12**, and a second stage turbine **27** receiving the exhaust from the first stage turbine **26**. The first stage turbine **26** is configured as a velocity turbine, also known as an impulse turbine, and recovers the kinetic energy of the core exhaust gas while creating minimal or no back pressure to the exhaust of the engine core **12**. The second stage turbine **27** is configured as a pressure turbine, also known as a reaction turbine, and completes the recovery of available mechanical energy from the exhaust gas. Each turbine **26**, **27** may be a centrifugal or axial device with one or more rotors having a circumferential array of radial, axial or mixed flow blades. In another embodiment, the turbine section **18** may include a single turbine, configured either as an impulse turbine or as a pressure turbine.

A pure impulse turbine works by changing the direction of the flow without accelerating the flow inside the rotor; the fluid is deflected without a significant pressure drop across the rotor blades. The blades of the pure impulse turbine are designed such that in a transverse plane perpendicular to the direction of flow, the area defined between the blades is the same at the leading edges of the blades and at the trailing edges of the blade: the flow area of the turbine is constant, and the blades are usually symmetrical about the plane of the rotating disc. The work of the pure impulse turbine is due only to the change of direction in the flow through the turbine blades. Typical pure impulse turbines include steam and hydraulic turbines.

In contrast, a reaction turbine accelerates the flow inside the rotor but needs a static pressure drop across the rotor to enable this flow acceleration. The blades of the reaction turbine are designed such that in a transverse plane perpendicular to the direction of flow, the area defined between the blades is larger at the leading edges of the blades than at the trailing edges of the blade: the flow area of the turbine reduces along the direction of flow, and the blades are usually not symmetrical about the plane of the rotating disc.

At least part of the work of the pure reaction turbine is due to the acceleration of the flow through the turbine blades.

Most aeronautical turbines are not "pure impulse" or "pure reaction", but rather operate following a mix of these two opposite but complementary principles—i.e. there is a pressure drop across the blades, there is some reduction of flow area of the turbine blades along the direction of flow, and the speed of rotation of the turbine is due to both the acceleration and the change of direction of the flow. The degree of reaction of a turbine can be determined using the temperature-based reaction ratio (equation 1) or the pressure-based reaction ratio (equation 2), which are typically close to one another in value for a same turbine:

$$\text{Reaction}(T) = \frac{(t_{S3} - t_{S5})}{(t_{S0} - t_{S5})} \tag{1}$$

$$\text{Reaction}(P) = \frac{(P_{S3} - P_{S5})}{(P_{S0} - P_{S5})} \tag{2}$$

where T is temperature and P is pressure, s refers to a static port, and the numbers refers to the location the temperature or pressure is measured: 0 for the inlet of the turbine vane (stator), 3 for the inlet of the turbine blade (rotor) and 5 for the exit of the turbine blade (rotor); and where a pure impulse turbine would have a ratio of 0 (0%) and a pure reaction turbine would have a ratio of 1 (100%).

In a particular embodiment, the first stage turbine **26** is configured to take benefit of the kinetic energy of the pulsating flow exiting the engine core **12** while stabilizing the flow and the second stage turbine **27** is configured to extract energy from the remaining pressure in the flow while expanding the flow. Accordingly, the first stage turbine **26** has a smaller reaction ratio than that of the second stage turbine **27**.

In a particular embodiment, the second stage turbine **27** has a reaction ratio higher than 0.25; in another particular embodiment, the second stage turbine **27** has a reaction ratio higher than 0.3; in another particular embodiment, the second stage turbine **27** has a reaction ratio of about 0.5; in another particular embodiment, the second stage turbine **27** has a reaction ratio higher than 0.5.

In a particular embodiment, the first stage turbine **26** has a reaction ratio of at most 0.2; in another particular embodiment, the first stage turbine **26** has a reaction ratio of at most 0.15; in another particular embodiment, the first stage turbine **26** has a reaction ratio of at most 0.1; in another particular embodiment, the first stage turbine **26** has a reaction ratio of at most 0.05.

It is understood that any appropriate reaction ratio for the second stage turbine **27** (included, but not limited to, any of the above-mentioned reaction ratios) can be combined with any appropriate reaction ratio for the first stage turbine **26** (included, but not limited to, any of the above-mentioned reaction ratios), and that these values can correspond to pressure-based or temperature-based ratios. Other values are also possible. For example, in a particular embodiment, the two turbines **26**, **27** may have a same or similar reaction ratio; in another embodiment, the first stage turbine **26** has a higher reaction ratio than that of the second stage turbine **27**. Both turbines **26**, **27** may be configured as impulse turbines, or both turbines **26**, **27** may be configured as pressure turbines.

Still referring to FIG. **1**, in the embodiment shown, the compressor rotor(s) **14'**, first stage turbine rotor(s) **26'** and second stage turbine rotor(s) **27'** are connected to (e.g. rigidly connected to, integrally formed with, attached to, or any other type of connection allowing the rotors to rotate together with the shaft at a same speed) the turbine shaft **19**, which extends through the gearbox module **20**, parallel and radially offset from (i.e. not co-axial with) the engine shaft **16**.

As can be seen in FIGS. **1** and **4**, the compressor rotor(s) **14'** and turbine rotor(s) **26'**, **27'** are cantilevered, i.e. the turbine shaft **19** is rotationally supported on only one side of the compressor rotor(s) **14'**, and on only one side of the turbine rotors **26'**, **27'**. The turbine shaft **19** is rotationally supported by a plurality of bearings **64** (e.g. rolling element bearings such as oil lubricated roller bearings and oil lubricated ball bearings, journal bearings) all located on a same side of the compressor rotor(s) **14'**, on a same side of the first stage turbine rotor(s) **26'**, and on a same side of the second stage turbine rotor(s) **27'**. In the embodiment shown, the bearings **64** are located between the compressor rotor(s) **14'** and the turbine rotors **26'**, **27'** and contained within the gearbox module casing **21**, without additional bearings being provided outside of the gearbox module **20**. The rotating assembly of the compressor module **24** and of the turbine module **28** is dynamically designed to rotate in a cantilevered manner, with the critical modes of deflection outside of the engine's operating conditions. Accordingly, the compressor module **24** and turbine module **28** do not include bearings, and are thus not part of the bearing lubricant circulation system **66**, which is contained within the gearbox module casing **21**. This eliminates the need to provide external lubricant (e.g. oil) feed or scavenge lines on the compressor module **24** and on the turbine module **28**, which may facilitate removal of the compressor module **24** and of the turbine module **28** from the remainder of the compound engine assembly **10**.

Alternately, the compressor **14** and turbine section **18** can each have their own dedicated shaft, for example for optimum component performance. In this case, the compressor shaft may also be only supported by bearings all located on a same side of the compressor rotor(s) **14'**, for example in the gearbox module casing **21**, such that the compressor rotor(s) **14'** are supported in a cantilevered manner. The compressor rotor(s) **14'** is in driving engagement with the turbine shaft **19** and/or the engine shaft **16**, for example by having the compressor shaft mechanically linked with the turbine shaft **19** and/or the engine shaft **16** through a gear train of the gearbox module **20**.

Still referring to FIG. **1**, the gearbox module **20** is a combining gearbox module **20**, including both a compounding gear train **68** and one or more accessory gear train(s) **70** contained in the gearbox module casing **21**. The turbine shaft **19** is mechanically linked to, and in driving engagement with, the engine shaft **16** through the compounding gear train **68**, such that the mechanical energy recovered by the turbine section **18** is compounded with that of the engine shaft **16**. In a particular embodiment, the compounding gear train **68** includes offset gears. In a particular embodiment, the elements of the compounding gear train **68** are configured to define a reduction ratio allowing each module to operate at its optimum operating speed. The reduction ratio may accordingly depend on engine sizing and/or other factors. In a particular embodiment, the reduction ratio is approximately 5:1; other values are also possible.

In a particular embodiment, having the compressor and turbine rotors **14'**, **26'**, **27'** on a same shaft **19** allows for the compounding gear train **68** to be lighter, as the compounding gear train is sized to transmit only the portion of the turbine power remaining after driving the compressor **14**.

It is understood that other types of gear trains are also possible, particularly, although not exclusively, for other configurations of the relative position between the modules. For example, in an alternate embodiment, the turbine section **18** and/or compressor section **14** may be positioned such that its rotating components rotate coaxially with the engine shaft **16**, and a planetary gear system may provide the mechanical link and driving engagement between the engine shaft **16** and the shaft of the turbine section **18** and/or compressor section **14**. Other configurations are also possible.

The accessory gear train(s) **70** connect (mechanically link) one or more accessories **72** with the engine shaft **16** and/or the turbine shaft **19**. The accessories **72** are mounted on the same face of the gearbox module casing **21** as the compressor module **24** and may include, but are not limited to, one or any combination of the following: starter, fuel pump, oil pump, coolant pump, aircraft hydraulic pump, aircraft air conditioning compressor, generator, alternator, permanent magnet alternator. In a particular embodiment, the accessory gear train **70** includes an offset gear system. Other configurations are also possible, including, but not limited to, the combination of offset and planetary gear systems.

Referring to FIGS. **3**-**4**, the proximity of the turbine module **28** to the core module **22**, and the gearbox module **20** located between the hot side (turbine module **28** and core module **22**) and the cold side (compressor module **24** and accessories **72**) enables the delimitation of a relatively small fire zone, which in a particular embodiment simplifies the design of the aircraft nacelle and of the fire suppression system, improving fire safety for the remainder of the compound engine assembly. In the embodiment shown, the compound engine assembly **10** includes a circumferential firewall **63** extending circumferentially around the gearbox module casing **21** and radially outwardly therefrom. The firewall **63** is located such that the hot zone or fire zone (turbine module **28**/core module **22**) is located on one side thereof, and the accessories **72** and compressor module **24** are located on the other side thereof—i.e. the axial location of the firewall **63** is between that of the turbine module **28** and core module **22**, and that of the accessories **72** and compressor module **24**.

Additional firewalls are provided to isolate the fuel system **13** from the hot turbine module **28** and the turbine exhaust pipes **30**. In the embodiment of FIG. **3**, two axial firewalls **65**, **67** extend from the circumferential firewall **63**; the axial firewalls **65**, **67** extend axially along the core module **22**, and radially outwardly therefrom. These two axial firewalls **65**, **67** are circumferentially spaced from one another such that the fuel system **13** is located therebetween; one of the firewalls **65** may be located at or about top dead center position of the rotary engines **12'**. In the embodiment shown, the axial firewalls **65**, **67** are respectively located at or about the 12 o'clock position (top dead center) and the 4 o'clock position. An additional circumferential firewall **69** is axially spaced from the first circumferential firewall **63** and extends between the axial firewalls **65**, **67**, circumferentially around part of the core module **22**, and radially outwardly from the core module **22**. The fuel system **13** is thus enclosed in a perimeter defined by the firewalls **63**, **65**, **67**, **69**, which separate it from the turbine module **28**, accessories **72** and compressor module **24**.

In a particular embodiment, the firewalls **63**, **65**, **67**, **69** extend radially outwardly to the position of the nacelle contour, such that the nacelle cooperates with the perimeter defined by the firewalls **63**, **65**, **67**, **69** to enclose the fuel system **13** separately from the accessories **72**, compressor module **24** and turbine module **28**, and cooperates with the first circumferential firewall **63** to enclose the turbine module **28** and core module **22** separately from the accessories **72** and compressor module **24**. In another embodiment, additional firewalls positioned radially inwardly of the nacelle contour may be provided to cooperate with the firewalls **63**, **65**, **67**, **69** to form the enclosure containing the fuel system **13** and the enclosure containing the turbine module **28** and core module **22** independently of the nacelle, in order to provide for smaller enclosures than the enclosures that would be defined by the nacelle.

In a particular embodiment, no electrical elements or accessories are included in the turbine module **28**, which reduces or eliminates the risk of fire in the turbine module **28** in case of fuel leak. Sensors and electrical elements other than those associated with the core module **22** are all located on the cold side of the gearbox module **20** where the temperature is not high enough to light a fire, and are separated from the hot zone by the firewall **63**; the fuel system **13** is further separated from the remainder of the hot zone, including the turbine module **28** and exhaust pipes **30**, by the firewalls **65**, **67**, **69**, to further minimize the risk of fire.

It is understood that in FIG. **3**, the firewalls **63**, **65**, **67**, **69** have been schematically illustrated as transparent for clarity purposes, to avoid obstructing view of the other components of the engine **10**, but that such illustration does not imply a need for the firewalls **63**, **65**, **67**, **69** to be made of transparent material. The firewalls **63**, **65**, **67**, **69** are made of any material which is sufficiently resistant to high temperature as per current certification requirements. In a particular embodiment, the firewalls **63**, **65**, **67**, **69** are made of a material able to resist a temperature of 2000° F. for 5 minutes. An example of suitable material is steel, but suitable other materials may be used.

Referring to FIG. **5**, the compound engine assembly **10** is a reversed flow assembly. The compound engine assembly **10** includes an inlet duct **74** having an inlet **76** communicating with ambient air outside of or around the assembly **10**, for example ambient air outside of a nacelle receiving the assembly. The inlet duct **74** includes an inertial particle separator **78** at its downstream end. Immediately downstream of the inertial particle separator **78**, the inlet duct communicates with a first conduit **80** communicating with the compressor **14** and a second conduit **82** defining an inlet bypass duct communicating with ambient air outside of or around the assembly **10**, for example through communication with the exhaust duct **84** (see FIG. **6**) of the compound engine assembly **10**. The first conduit **80** defines a sharp turn with respect to the inlet duct **74** (e.g. by extending approximately perpendicular thereto), extending at a sufficient angle from the inlet duct **74** such that the heavier particles (e.g. ice, sand) continue to the downwardly angled second conduit **82** while the air follows the sharp turn of the first conduit **80**. The section of the inlet duct **74** defining the inertial particle separator **78** and the first and second conduits **80**, **82** are sized to achieve adequate air velocities to ensure separation of the particles.

Still referring to FIG. **5**, during engine operation, the ambient air penetrates the compound engine assembly **10** through the inlet **76** of the inlet duct **74** on one end of the assembly **10**, and circulates through the inlet duct **74** in a first direction across a length of the assembly **10**. The air reaches the compressor **14** after having passed through the inertial particle separator **78**, turned into the conduit **80**, and circulated through a filter **86**. Inlet guide vanes **88** modulate the flow into the compressor **14**. The air is pressure boosted by the compressor **14** and routed to the engine core **12**; although not shown, the air flow between the compressor **14** and engine core **12** may circulate in part or in whole through an intercooler. The engine core **12** further compresses the air. Fuel is injected in the engine core **12** and combusted, and work is extracted during the expansion cycle of the engine core **12**. Exhaust from the engine core **12** is circulated to the turbine section **18**. Work is further extracted by the turbines (e.g. impulse turbine, then pressure turbine) to drive the compressor **14**, and the remaining useful work is transmitted to the engine shaft **16** via the gearbox module **20**. The air/gases circulation from the compressor **14** to the turbine section **18** is done along a direction generally opposite of that of the air circulation within the inlet duct **74**, such that the exhaust gases exit the turbine section **18** near the same end of the assembly **10** as the inlet **76** of the inlet duct **74**.

In the embodiment shown, a fraction of the turbine exhaust flow is used for anti-icing/de-icing of the inlet **76** of the assembly **10**. The turbine exhaust communicates with a first exhaust conduit **90** communicating with the exhaust duct **84** and with a second exhaust conduit **91** communicating with one or more conduits **92** located in the lip of the inlet **76**, which then also communicate with the ambient air outside of or around the assembly **10**, for example directly, through communication with the exhaust duct **84**, or through communication with the second conduit (inlet bypass duct) **82**. A valve **94** can be provided at the entry of the second exhaust conduit **91** to regulate the flow of exhaust air being circulated in the lip conduit(s) **92** and/or to close the flow when de-icing is not necessary.

In addition or in the alternative, anti-icing could be achieved with hot coolant from a heat exchanger (cooler) **96** (see FIG. **6**) of the assembly **10**, for example by having part of a hot coolant flow exiting the engine core **12** circulating through a coil tube **98** disposed in the lip of the inlet **76** before being circulated to the associated heat exchanger **96**.

Still referring to FIG. **5**, it can be seen that the turbine shaft **19** is parallel to and radially offset from (i.e., non-coaxial to) the engine shaft **16**, and that both shafts **16**, **19** are radially offset from (i.e., non-coaxial to) the inlet duct **74**. In the embodiment shown, the shafts **16**, **19** are radially offset from a longitudinal central axis **100** of at least part of the inlet duct **74**, or of the whole inlet duct **74**. The air flow within the inlet duct **74** occurs along a direction corresponding to or substantially corresponding to that of the central axis **100**. It is understood that the central axis **100** may be a straight line (straight duct) or a curved line (curved duct e.g. single curve, S-shaped). In a particular embodiment, the central axis **100** is parallel to the shafts **16**, **19**. Other configurations are also possible, including, but not limited to, the central axis **100** extending at a non-zero angle with respect to the shafts **16**, **19**. In embodiments where the inlet duct **74** has a curved shape (e.g.), an imaginary line may be defined as the straight line more closely corresponding to the curved central axis of the inlet duct **74**; this imaginary line may be parallel to the shafts **16**, **19** or extend at a non-zero angle with respect thereto.

FIG. **6** shows an example of relative angular positions of the turbine shaft **19**, the assembly inlet **76** and inlet duct **74**, a lubricant (e.g. oil) heat exchanger **102** for cooling of the oil or other lubricant circulated through the compound engine assembly **10** (e.g. to lubricate the bearings of the shafts **16**, **19** and the rotor(s) of the engine core **12**), and the coolant (e.g. water) heat exchanger **96** for cooling the coolant circulated through the housing of the engine core **12**. In a particular embodiment, the layout of the compound engine assembly **10** is suitable for a compact streamlined nacelle with minimum aircraft drag.

The radial offset of the turbine shaft **19** and of the inlet duct **74** with respect to the engine shaft **16** allows for the compressor and turbine modules **24**, **28**, inlet duct **74**, and heat exchangers **96**, **102** to be clockable around the engine shaft **16**, i.e. to be disposed in a variety of angular positions around the engine shaft **16** to suit specific aircraft nacelle designs. For example, the configuration of FIG. **6** could be modified by placing the compressor and turbine modules **24**, **28** closer to the nacelle exhaust, e.g. more toward the bottom of the assembly **10**, to reduce or minimize the length of the exhaust duct **84** and/or exhaust conduits **90**, **91** connected to the exhaust duct **84**. The angular position of the assembly inlet **76** and inlet duct **74** around the engine shaft **16** can also be changed to suit specific aircraft nacelle designs. The coolant and lubricant heat exchangers **96**, **102** can for example be located on the sides of the core module **22**, at the top of the core module **22**, or behind the core module **22** as suitable for the particular aircraft associated with the compound engine assembly **10** and/or to provide increased accessibility to the heat exchangers **96**, **102** and other components for ease of maintenance, repair and/or replacement. The accessories **72** may be located all at a same angular position, and clocked around the core module **22** as required with respect to available space to receive the compound engine assembly **10**. In a particular embodiment, locating all of the accessories **72** at a same angular position allows for all of the accessories **72** to be accessible through a single compartment access panel.

Referring back to FIG. **4**, in a particular embodiment the compound engine assembly **10** is mounted to the aircraft through a mount cage **104** including struts **106** connected to two opposed side mounts **105** attached to the casing **21** of the gearbox module **20**. In the embodiment shown, two struts **106** are connected to each side mount **105** through an isolator **103**, which may include for example a suitable elastomeric material. The struts **106** extending from the same mount **105** are angled with respect to one another such as to extend further apart from each other as distance from the mount **105** increases. The mount cage **104** includes a lower transverse bar **106'** interconnecting the two lower struts extending from different mounts, and an upper transverse bar **106"** interconnecting the two upper struts extending from different mounts; the struts **106** are interconnected by the bars **106'**, **106"** at their ends opposite the mounts **105**, which are configured to be attached to the aircraft (e.g. to a bulkhead of the aircraft). An arcuate support **107** extends under the engine **10** between the mounts **105**. The struts **106** are positioned such as to avoid crossing the exhaust pipes **30**. In a particular embodiment, such a configuration avoids having any hot gas leak from the core engine exhaust pipes **30** into the turbine module **28** impinging onto the mount structure (including isolators **103**, fasteners, etc.), and thus avoids compromises in mount structural integrity which could result from such leaks impinging onto the mount structure.

In the embodiment shown, the mount cage **104** and the mounts are located out of the fire zone (turbine module **28**/core module **22**). The mount cage **104**, including the struts **106** and the transverse bars **106'**, **106"**, as well as the mounts are located on the “cold side” of the gearbox module casing **21**, and separated from the turbine module **28**, core module **22** and exhaust pipes **30** by the firewall **63**. The mount cage **104** is thus completely contained within an axial space extending axially from a first location at the cold end of the assembly to a second location on the gearbox module casing **21**, with the turbine module **28**, core module **22** and exhaust pipes **30** being located outside of this axial space. Accordingly, the struts **106** are not challenged by the hot temperature of the turbine module **28**, exhaust pipes **30** and core module **22**, which may help improve the structural integrity of the mount cage **104** and of its connection with the engine **10**.

Referring to FIGS. **7**-**10**, a compound engine assembly **210** according to an alternate embodiment is shown, where elements similar to or identical to the corresponding elements of the compound engine assembly **10** are identified by the same reference numerals and will not be further described herein. As shown in FIGS. **7**-**8**, the compound engine assembly **210** is configured as a reversed flow single shaft engine and includes five (5) major modules: the core module **22**, the gearbox module **20**, the cold section/compressor module **24**, the hot section/turbine module **28**, and a reduction gearbox module **220**. In the compound engine assembly **210**, the rotatable load driven by the engine shaft **16** of the core module **22** is a propeller **208**. The engine shaft **16** is engaged to the propeller **208** through the reduction gearbox module **220**. The core module **12** is depicted as including three (3) rotary engines **12'**, but is it understood that any other adequate number of rotary engines or of other types of internal combustion engines may be used.

In the embodiment shown, the reduction gearbox module **220** comprises a planetary gearbox system; other configurations are also possible, including, but not limited to, offset gearbox and double-branch offset gear train. Although not shown, additional accessories may be mechanically linked to and drivingly engaged to the reduction gearbox module.

Referring to FIG. **9**, in use, the ambient air penetrates the compound engine assembly **210** through the inlet **76** of the inlet duct **74**, circulates through the inlet duct **74**, through the inertial particle separator **78**, changes direction to circulate across the filter **86**, inlet guide vanes **88**, compressor **14**, optional intercooler **217** (see FIG. **10**), and engine core **12**. Exhaust from the engine core **12** is circulated to the turbine section **18** (which may include two turbine stages as previously described), where work is further extracted to drive the compressor. The remaining useful work is transmitted to the engine shaft **16** via the gearbox module **20**. It can be seen that a fraction of the turbine exhaust flow can be circulated to the lip conduit **92** for anti-icing of the lip of the inlet **76**, as described above.

The firewall **63** extends from the gearbox module casing **21** between the fire zone (turbine module **28**/core module **22**) and the accessories **72** and compressor module **24**, as described above.

The compound engine assembly **210** also includes a turbine shaft **19** parallel to and radially offset from (i.e., non-coaxial to) the engine shaft **16**, with both shafts being radially offset from (i.e., non-coaxial to) the central axis **100** extending along the length of part of or of the whole of the inlet duct **74**. The central axis **100** may be parallel to the shafts **16**, **19**, may be a straight line extending at a non-zero angle with respect to the shaft **16**, **19** or may be curved (e.g. single curve, S-shaped). In embodiments where the inlet duct **74** has a curved shape an imaginary line may be defined as the straight line more closely corresponding to the curved central axis of the inlet duct **74**; this imaginary line may be parallel to the shafts **16**, **19** or extend at a non-zero angle with respect thereto. The radial offset of the turbine shaft **19** and of the inlet duct **74** with respect to the engine shaft **16** allows for the compressor and turbine modules **24**, **28**, inlet duct **74** and heat exchangers **96**, **102** to be clockable around the engine shaft **16**, i.e. to be disposed in a variety of angular positions around the engine shaft **16** to suit specific aircraft nacelle designs, as described above.

Referring to FIG. **10**, the compound engine assembly **210** also includes a mount cage **104** including angled struts **106** connected to opposed side mounts **105** attached to the casing **21**, and configured such that the struts **106** do not cross the exhaust pipes **30**; transverse bars **106'**, **106"** respectively interconnecting the two lower struts and the two upper struts extending from different mounts; and an arcuate support **107** extending under the engine **210** between the mounts **105**. An additional arcuate support **207** may be provided under the engine **210** to support the reduction gearbox module **220**, and a link **209** may extend on each side of the engine **210** between the two arcuate supports **107**, **207**; alternately, the additional support **207** and links **209** may be omitted. As described above, in a particular embodiment the mount cage **104** and the mounts **105** are separated from the turbine module **28**, core module **22** and exhaust pipes **30** by the firewall **63** (FIG. **8**).

Referring to FIGS. **11**-**12**, a compound engine assembly **310** according to an alternate embodiment is shown, where elements similar to or identical to the corresponding elements of the compound engine assemblies **10**, **210** are identified by the same reference numerals and will not be further described herein. The compound engine assembly **310** is configured as a reversed flow single shaft engine and includes four (4) major modules: the core module **22**, the cold section/compressor module **24**, the hot section/turbine module **28**, and the gearbox module including first and second sub-modules or parts **320**, **320'** which cooperate to together define a module similar to the gearbox module **20** previously described. Although not shown, the compound engine assembly **310** could be configured as a turboprop engine with a reduction gearbox module.

In a particular embodiment, the compound engine assembly **310** is, aside from its gearbox module **320**, **320'** configured similarly or identically to the compound engine assembly **10** or to the compound engine assembly **210** previously described; it is accordingly understood that any element and combination of elements of the assemblies **10**, **210** as previously described, can be used in the assembly **310**.

The first part **320** of the gearbox module includes a casing **321** containing (e.g. enclosing) a first part **368** of the compounding gear train (shown here as a pinion gear), and the second part **320'** of the gearbox module includes a casing **321'** containing a complementary part **368'** of the compounding gear train. The two gearbox module casings **321**, **321'** are detachably interconnected; in the embodiment shown, the casings **321**, **321'** include complementary flanges **323**, **323'** which are bolted together with a setting spacer **331** therebetween. However, any other suitable type of connection may be used, including but not limited to those described above.

The turbine shaft **19**, to which the rotors of the turbine module **28** and of the compressor module **24** are connected to (e.g. rigidly connected to, integrally formed with, attached to, or any other type of connection allowing the rotors to rotate together with the shaft at a same speed), extends through the second part **320'** of the gearbox module. The parts **368**, **368'** of the compounding gear train cooperate to mechanically link and in drivingly engage the turbine shaft **19** to the engine shaft **16**. The rotors of the turbine module **28** and of the compressor module **24** are cantilevered, and the bearings **64** supporting the turbine shaft **19** are contained within the casing **321'** of the second part **320'** of the gearbox module, without additional bearings being provided outside of the gearbox module. Alternately, the turbine module **28** and of the compressor module **24** can each have their own dedicated shaft. The compressor module **24** and turbine module **28** do not include bearings, and are thus not part of the bearing lubricant circulation system, which is contained within the second gearbox module casing **321'**.

The compressor module casing **25** is located outside of the gearbox module casings **321**, **321'**, and is mounted on a face of the second gearbox module casing **321'** (e.g. detachably interconnected through any suitable type of connection, including but not limited to those described above). The turbine module casing **29** is also located outside of the gearbox module casings **321**, **321'**, and is mounted on the face of the second gearbox module casing **321'** opposite that receiving the compressor module casing **25** (e.g. detachably interconnected through any suitable type of connection, including but not limited to those described above).

The first part **320** of the gearbox module includes one or more accessory gear train(s) (not shown) contained in the first gearbox module casing **321**. Accessories (not shown) are engaged mounted on a face of the first gearbox module casing **321** on a same side of the gearbox module **320**, **320'** as the compressor module **25**.

The separate gearbox module casings **321**, **321'** may allow the turbine module **28**, compressor module **24** and second part **320'** of the gearbox module to be separated from the remainder of the engine **310** while remaining interconnected to one another to define a "turbo machinery module" which may be replaced, or serviced independently of the remainder of the engine **310**.

In a particular embodiment, the separate gearbox module casings **321**, **321'** allows the second casing **321'** adjacent the turbine module **28** to be made of material more resistant to heat than that of the first casing **321**, which may help minimize cooling requirements and/or thermal protection requirement, as opposed to a single gearbox module casing completely made of the material of the first casing **321**. In a particular embodiment, the first casing **321** is made of aluminium, and the second casing **321'** is made of steel.

Although not shown, the engine **310** includes mounts for engagement with a mounting structure, such as a mount cage **104** as previously described. In a particular embodiment, the mounts are connected to the first gearbox module casing **321**.

Although examples of the compound engine assembly **10**, **210**, **310** have been shown as turboshaft and turboprop engine assemblies, it is understood that the compound engine assemblies can be designed for other uses, including, but not limited to, to be used as an auxiliary power unit.

The above description is meant to be exemplary only, and one skilled in the art will recognize that changes may be made to the embodiments described without departing from the scope of the invention disclosed. Modifications which fall within the scope of the present invention will be apparent to those skilled in the art, in light of a review of this disclosure, and such modifications are intended to fall within the appended claims.

The invention claimed is:

1. A compound engine assembly comprising:

an inlet duct having a longitudinal central axis, an air flow within the inlet duct occurring along a direction corresponding to that of the longitudinal central axis;

a conduit communicating with the inlet duct;

a compressor having an inlet in fluid communication with the conduit, the compressor including at least one compressor rotor connected to a turbine shaft;

an engine core including at least one internal combustion engine in driving engagement with an engine shaft, the engine core having an inlet in fluid communication with an outlet of the compressor;

a turbine section having an inlet in fluid communication with an outlet of the engine core, the turbine section including at least one turbine rotor connected to the turbine shaft, the turbine shaft configured to compound power with the engine shaft;

wherein the turbine shaft and the engine shaft are parallel to each other; and

wherein the turbine shaft, the engine shaft and the longitudinal central axis of at least part of the inlet duct are all radially offset from one another, the at least part of the inlet duct including an inlet of the inlet duct in fluid communication with ambient air around the compound engine; wherein the longitudinal axis of at least part of the inlet duct is parallel to the turbine shaft and to the engine shaft, and wherein the engine assembly is a reversed flow assembly such that the inlet of the inlet duct is closer to the turbine section than to the compressor.

2. The compound engine assembly as defined in claim **1**, wherein the longitudinal central axis of a majority of the inlet duct is radially offset from the turbine shaft and from the engine shaft.

3. The compound engine assembly as defined in claim **1**, wherein the turbine shaft is connected to the engine shaft through a gearbox.

4. The compound engine assembly as defined in claim **3**, wherein the gearbox is located between the compressor and the turbine section.

5. The compound engine assembly as defined in claim **1**, wherein the compressor and the turbine section are respectively provided in a compressor module casing and in a turbine module casing, the compressor module and turbine module casings being spaced from one another and removable from the assembly independently from one another.

6. The compound engine assembly as defined in claim **1**, wherein each of the at least one internal combustion engine includes a rotor sealingly and rotationally received within a respective internal cavity to provide rotating chambers of variable volume in the respective internal cavity, the rotor having three apex portions separating the rotating chambers and mounted for eccentric revolutions within the respective internal cavity, the respective internal cavity having an epitrochoid shape with two lobes.

7. The compound engine assembly as defined in claim **1**, wherein the turbine section includes a first stage turbine having an inlet in fluid communication with the outlet of the engine core, and a second stage turbine having an inlet in fluid communication with an outlet of the first stage turbine.

8. The compound engine assembly as defined in claim **7**, wherein the first stage turbine is configured as an impulse turbine with a pressure-based reaction ratio having a value of at most 0.2, the second stage turbine having a higher reaction ratio than that of the first stage turbine.

9. A compound engine assembly comprising:

an inlet duct having an inlet in fluid communication with ambient air around the compound engine assembly;

a compressor having an inlet in fluid communication with the inlet duct;

an engine core including at least one internal combustion engine in driving engagement with an engine shaft, the engine core having an inlet in fluid communication with an outlet of the compressor;

a turbine section including a first stage turbine having an inlet in fluid communication with the outlet of the engine core and a second stage turbine having an inlet in fluid communication with an outlet of the first stage turbine, each of the first stage turbine and the second stage turbine including at least one rotor connected to a turbine shaft, the turbine shaft and the engine shaft being in driving engagement with one another;

wherein the turbine shaft and the engine shaft are parallel to each other; and

wherein the turbine shaft, the engine shaft and at least part of the inlet duct are all radially offset from one another, the at least part of the inlet duct including an inlet of the inlet duct in fluid communication with ambient air around the compound engine assembly; wherein a longitudinal axis of at least part of the inlet duct is parallel to the turbine shaft and to the engine shaft, and wherein the engine assembly is a reversed flow assembly such that the inlet of the inlet duct is closer to the turbine section than to the compressor.

10. The compound engine assembly as defined in claim **9**, wherein a longitudinal central axis of at least part of the inlet duct is radially offset from the turbine shaft and from the engine shaft.

11. The compound engine assembly as defined in claim **9**, wherein the turbine shaft is connected to the engine shaft through a gearbox.

12. The compound engine assembly as defined in claim **11**, wherein the gearbox is located between the compressor and the turbine section.

13. The compound engine assembly as defined in claim **9**, wherein the compressor and the turbine section are respectively provided in a compressor module casing and in a turbine module casing, the compressor module and turbine module casings being separate from one another and removable from the assembly independently from one another.

14. The compound engine assembly as defined in claim **9**, wherein each of the at least one internal combustion engine includes a rotor sealingly and rotationally received within a respective internal cavity to provide rotating chambers of variable volume in the respective internal cavity, the rotor having three apex portions separating the rotating chambers and mounted for eccentric revolutions within the respective internal cavity, the respective internal cavity having an epitrochoid shape with two lobes.

15. The compound engine assembly as defined in claim **9**, wherein the first stage turbine and the second stage turbine have different reaction ratios.

16. The compound engine assembly as defined in claim **9**, wherein the first stage turbine is configured as an impulse turbine with a pressure-based reaction ratio having a value of at most 0.2, the second stage turbine having a higher reaction ratio than that of the first stage turbine.

17. A method of driving a rotatable load of an aircraft, the method comprising:

directing ambient air from outside of the compound engine assembly into the compound engine assembly through an inlet duct;

directing the air from the inlet duct to an inlet of a compressor;

directing compressed air from an outlet of a compressor to an inlet of at least one internal combustion engine of a compound engine assembly;

driving rotation of an engine shaft with the at least one combustion engine;

driving rotation of a turbine shaft of a turbine section of the compound engine assembly by circulating an exhaust of the at least one internal combustion engine to an inlet of the turbine section; and

compounding power from the turbine shaft with that of the engine shaft to drive the rotatable load;

wherein the turbine shaft and the engine shaft are parallel to each other and radially offset with respect to each other; and

wherein the air is circulated through the inlet duct from an inlet thereof along a path radially offset from the turbine shaft and from the engine shaft; wherein the path along which the air is circulated is parallel to the turbine shaft and to the engine shaft, and wherein the engine assembly is a reversed flow assembly such that the inlet of the inlet duct is closer to the turbine section than to the compressor.

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